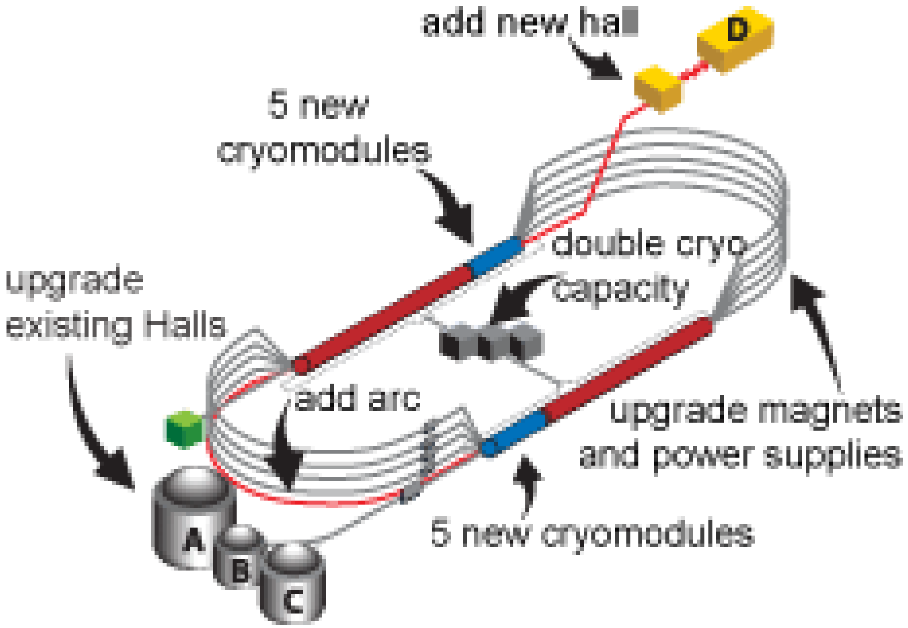
SoLID Heavy Gas Cherenkov Prototype

Rory Evans

Supervisor: Dr. Garth Huber

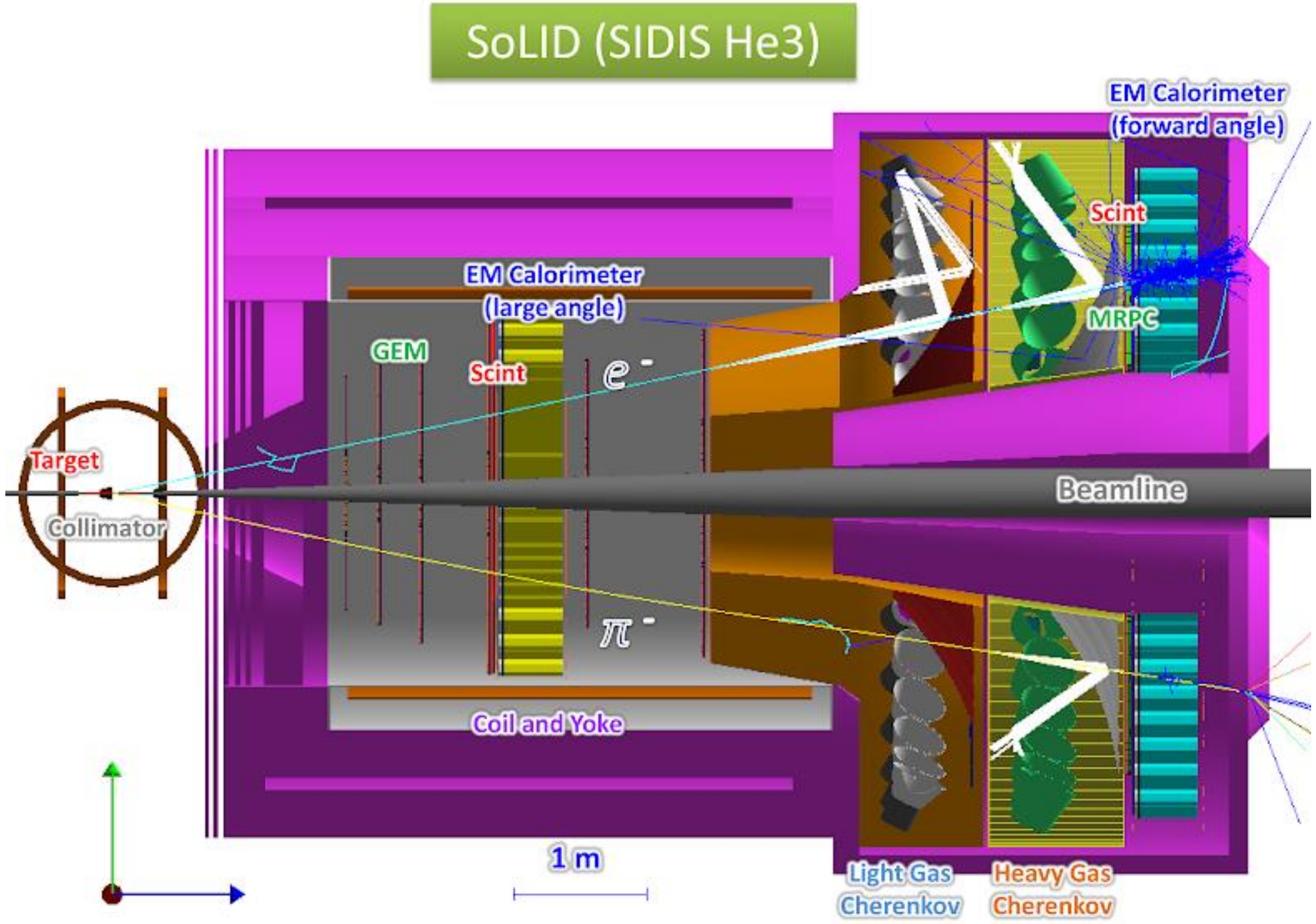
University of Regina

Jefferson Lab



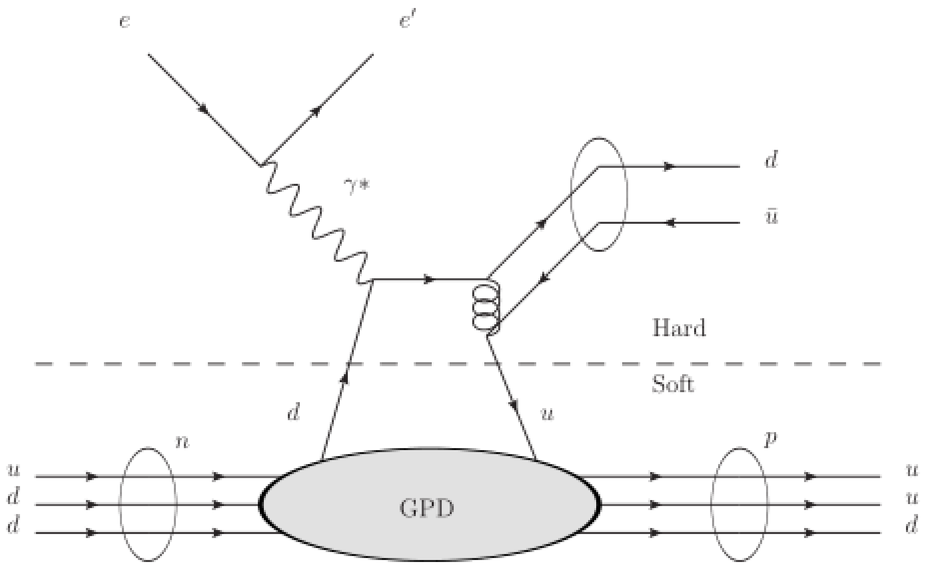
SoLID – Solenoidal Large Intensity Device

- Large acceptance, high luminosity, high rate detector for 12 GeV era of JLab science.
- 2 Configurations – SIDIS and PVDIS.
- Polarized Helium-3 Cryogenic Target for SIDIS.
- HGC only in SIDIS
- 360° azimuthal coverage
- 8° to 14.8° (24°) polar coverage for electrons (pions)



DEMP – Deep Exclusive Meson Production

$\overrightarrow{n}(e, e'\pi^-)p$



- GPDs consolidate all information included in Hadronic Form Factors and PDFs
- 4 leading order GPDs: $E, H, \tilde{E}, \tilde{H}$
- Measurement of $\tilde{E}$ GPD through Single Spin Asymmetry.

DEMP – Azimuthal Modulations

- Single spin asymmetry function of angle between electron and target polarization
- Scaling expected at $Q^2 \sim 2 - 4\mathrm{GeV}^2$

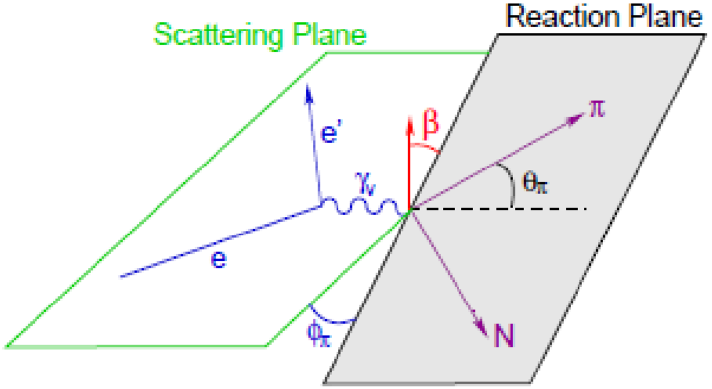
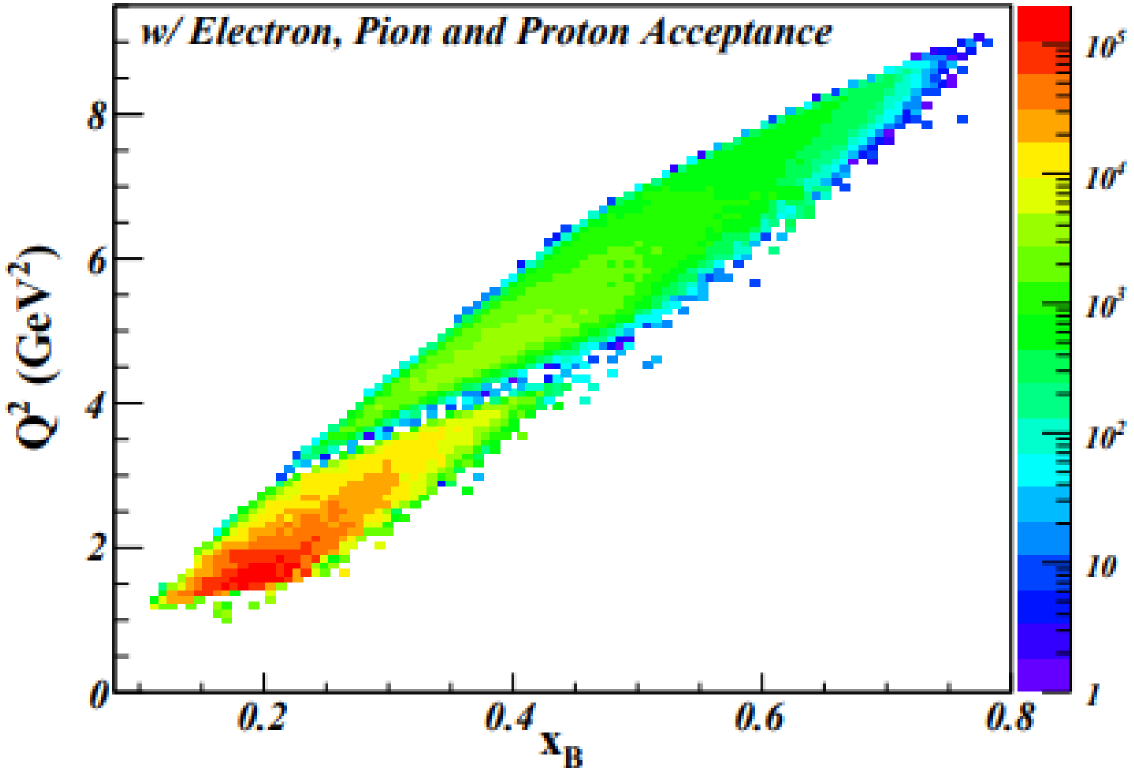
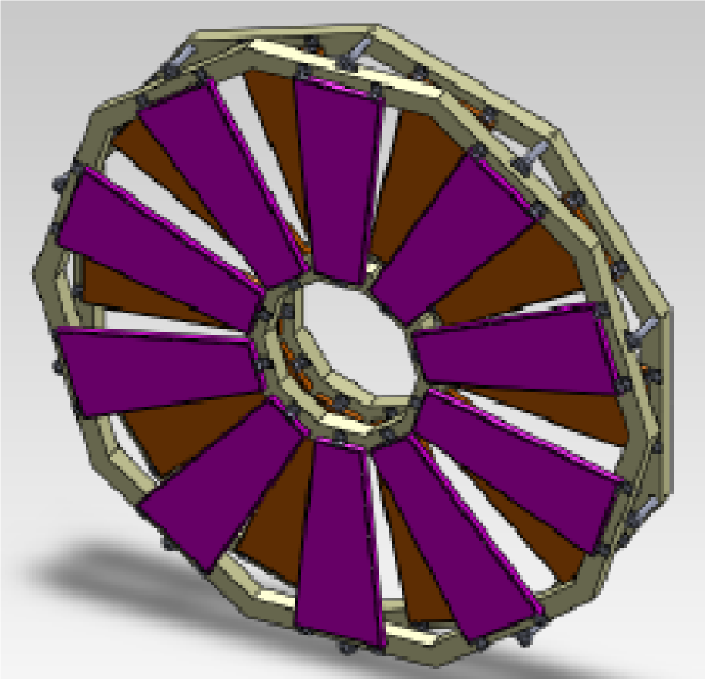


Figure: DEMP coordinate system [2]

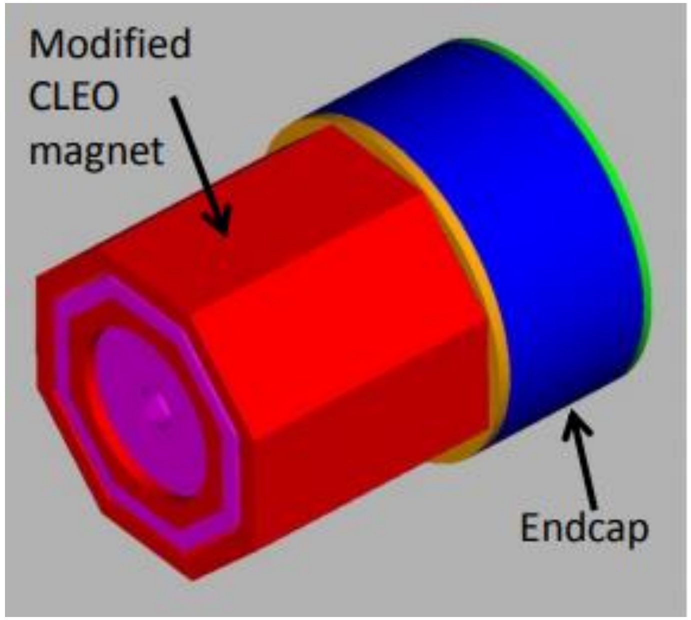


Expected Kinematic coverage with SoLID

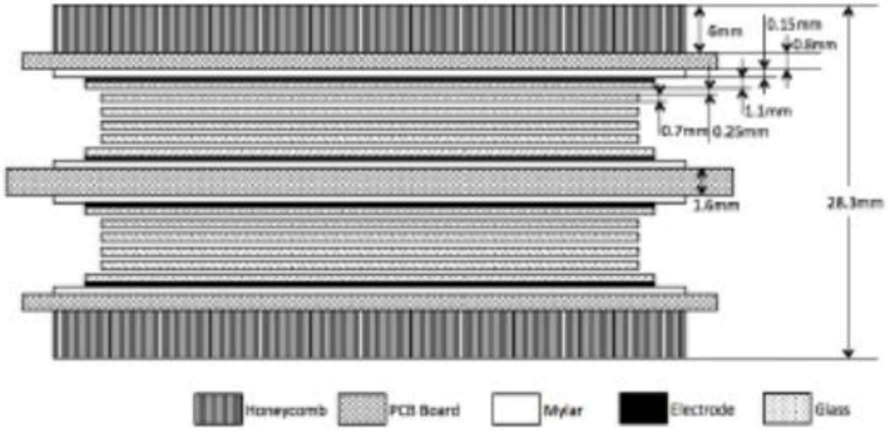
SoLID – GEM Trackers and CLEO-II Magnet

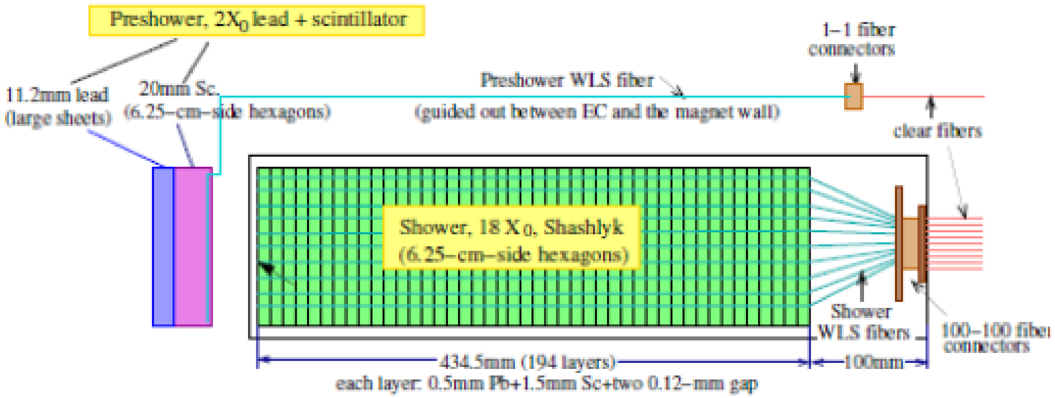


- **G**as **E**lectron **M**ultiplier: New Gas Avalanche based detector with 2D readout
- 6 Planes give 3D particle track
- Housed inside 1.5T solenoidal magnet
- Curve of particle track gives momentum and charge sign.



SoLID –MRPC and Calorimeter

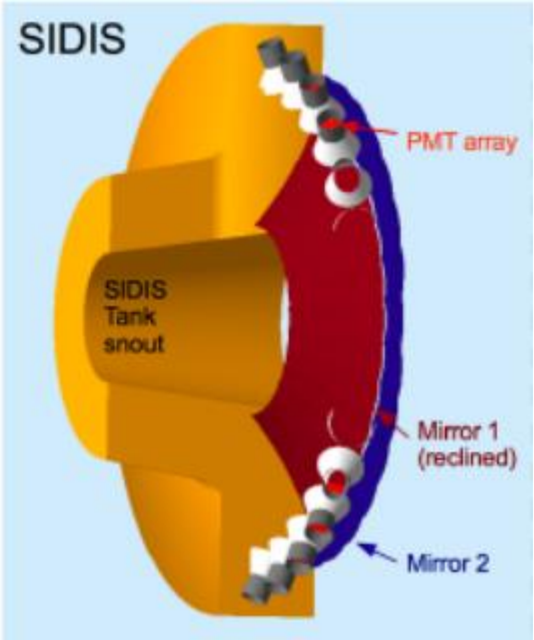


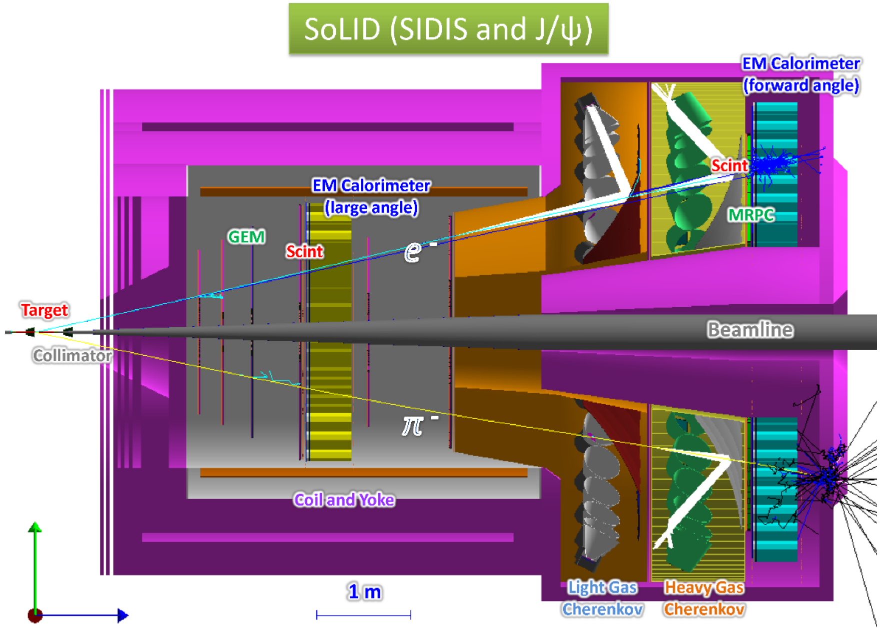


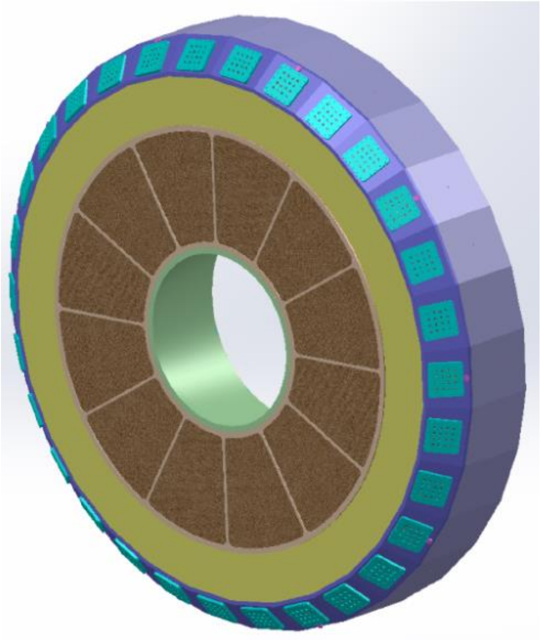
- MRPC – Multigap Resistive Plate Chamber
- Gas Avalanche type detector
- TOF and pion id
- Between HGC and FAEC
- Time resolution of 100 ps

- "Shashlyck" style Electromagnetic Calorimeter module
- Layers stacked longitudinally to beam direction
- Allows reconstruction of shower profile
- One large angle EC (LAEC) inside magnet, one forward angle EC (FAEC) at back of end cap.

SoLID – Light and Heavy Gas Cherenkovs



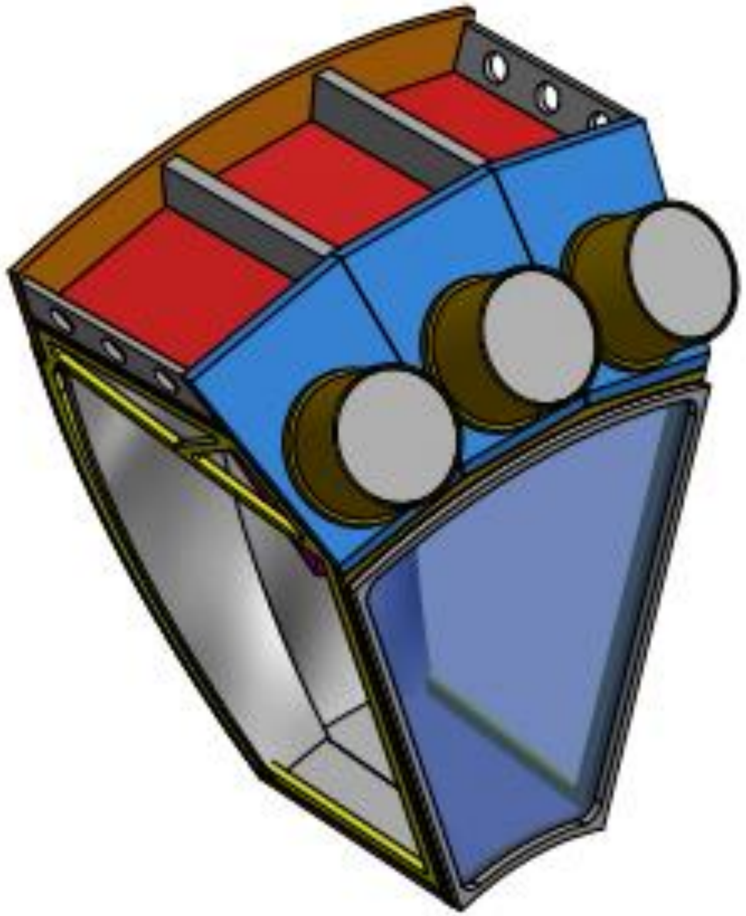




- LGC: Pion/Electron Separation
- CO_2 Gas at 1 atm
- $n = 1.0004$

- HGC: Pion/Kaon Separation
- C_4F_{10} at 1.5 atm

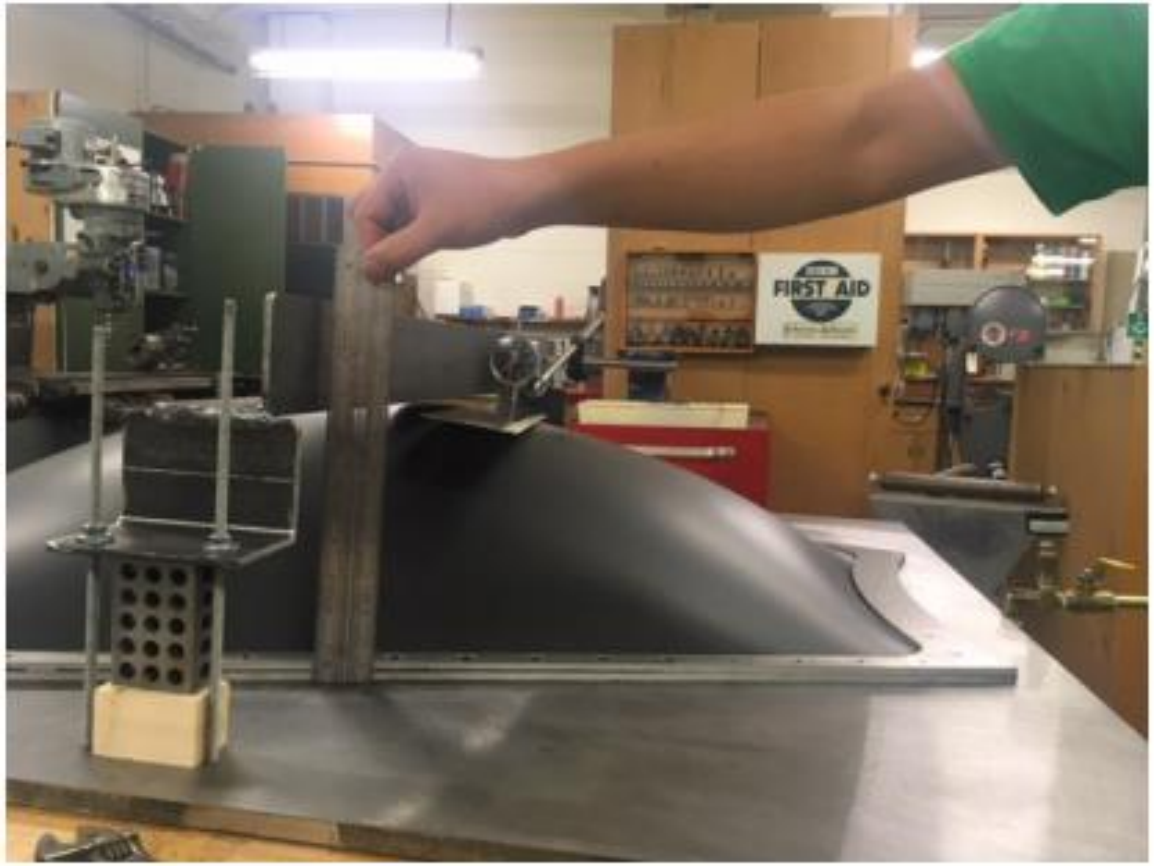
Heavy Gas Cherenkov Prototype



- Collaboration between University of Regina and Duke University to build a prototype segment of the HGC
- Must have negligible leaking over long periods of time at 1.5 atm
- Must be strong enough to hold 2 atm without failure (2x overpressure safety factor)
- Most probable point of failure is entry window
- Window must be thin and low-Z to minimize data impact, while also strong enough to hold the pressure.
- Proximity of LGC imposes limits on bulging in entry window – ideally less than 10 cm

HGC Window – PET/Tedlar Composite

- First attempt used a three layer plastic: 1.5 mil Tedlar, 3 mil PET, 1.5 mil Tedlar from Madico Inc.
- Has the advantage of being both air-tight and light-tight
- Bulged more than 14 cm at 1.5 atm
- Did not leak at 1.5 atm, but could not handle 2x safety factor



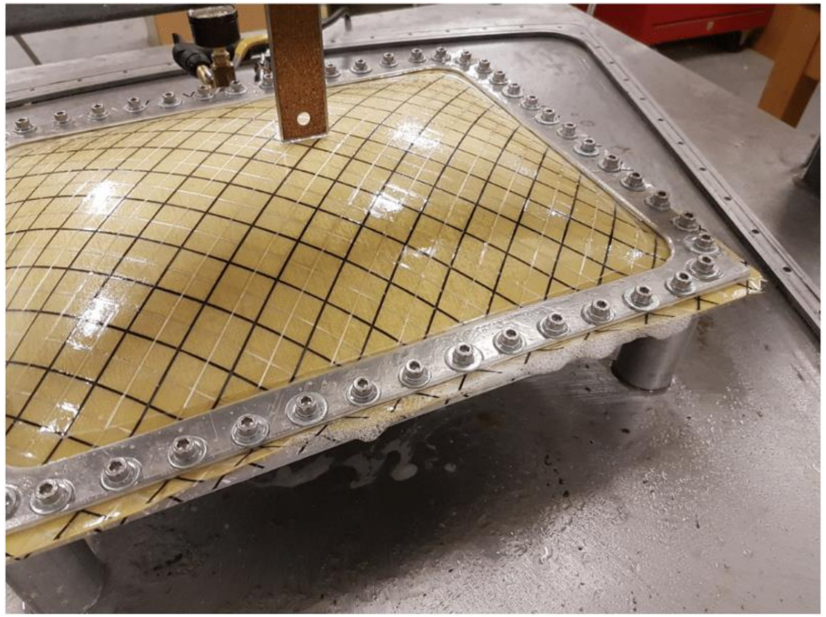
HGC Window – PET/Tedlar Composite

HGC Window – Kevlar and Mylar

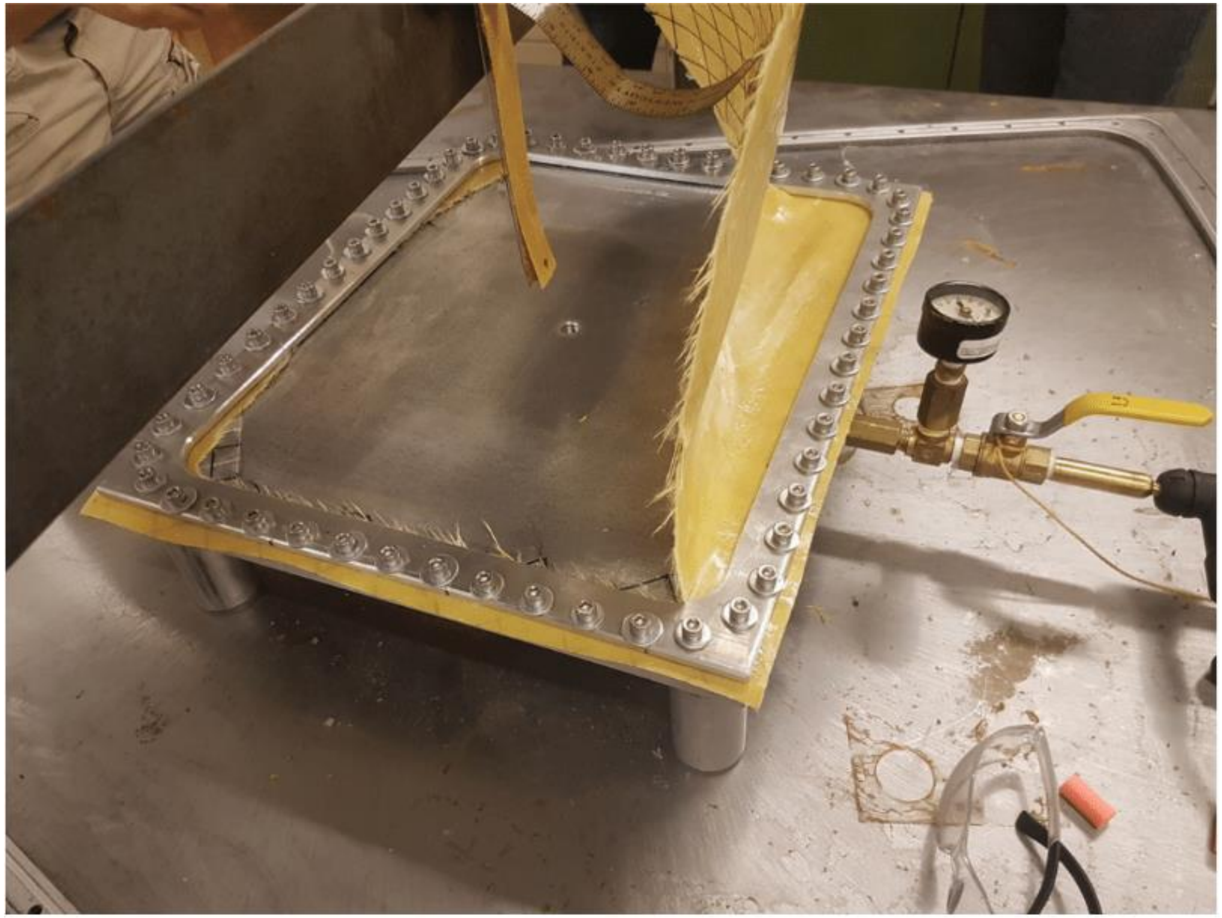
- 5 mil Mylar and 12 mil Kevlar from Challenge Sailcloth
- Approx. 5 cm bulge at 1.5 atm
- Burst before reaching 2 atm

HGC Window – Kevlar and Mylar

- Tried epoxy on the frame
- Moved to small scale model to save material
- Estimated need for 4x pressure increase to compensate



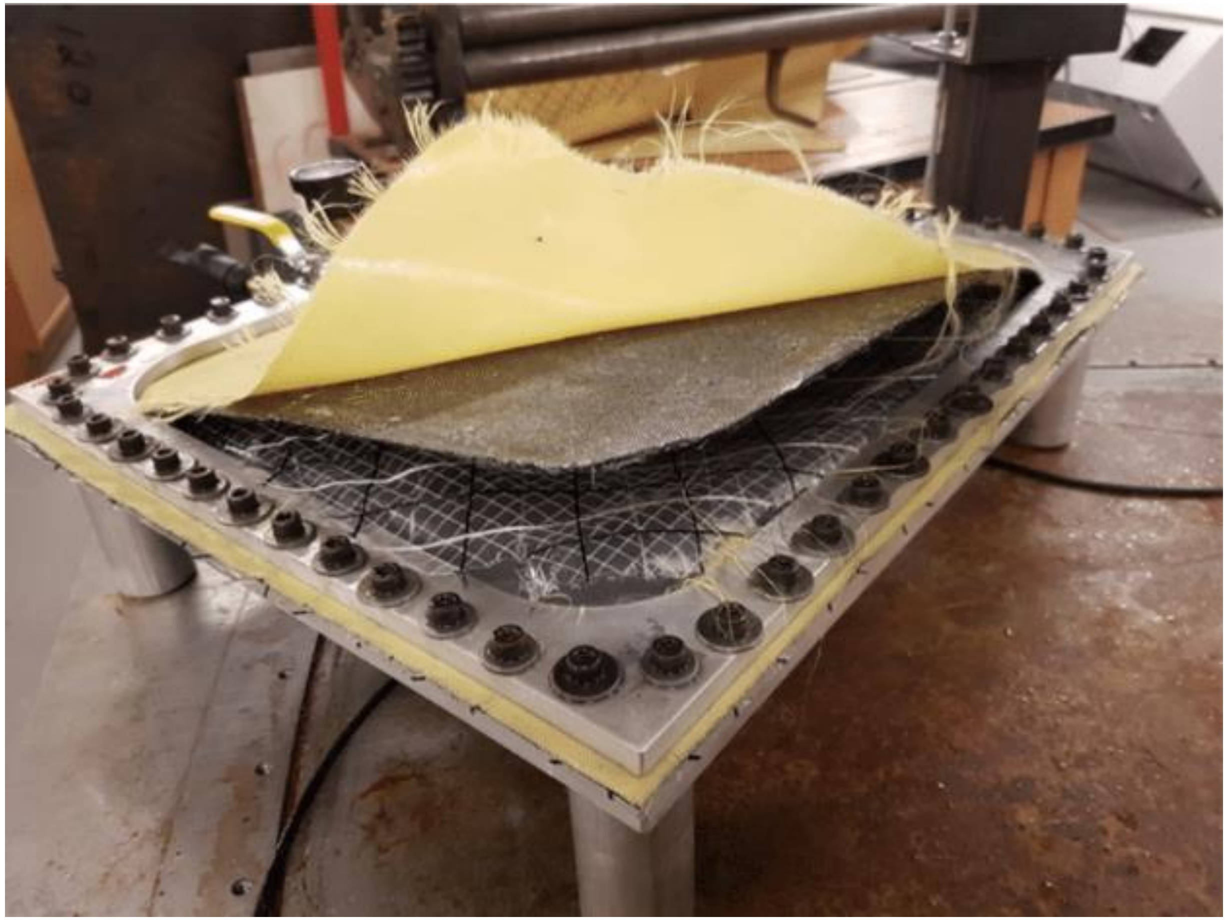
HGC Window – Kevlar and Mylar



HGC Window – Carbon Fiber

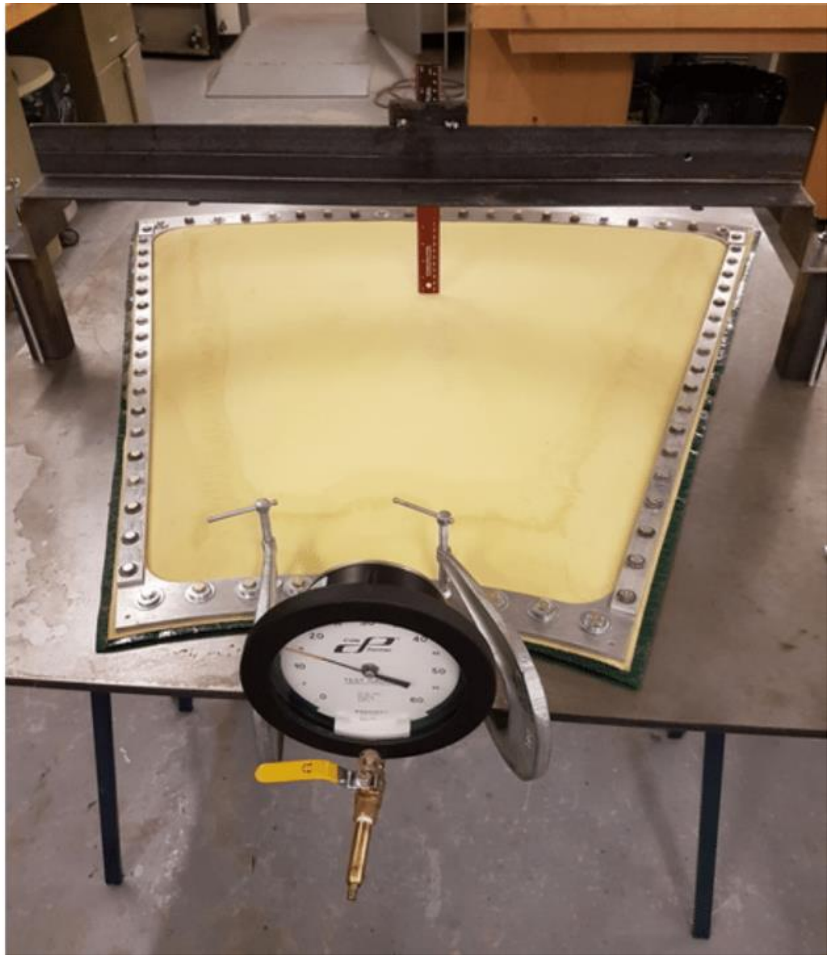
- Carbon Fiber fabric brushed with epoxy, vacuum bagged, and hardened to desired shape.
- Kevlar added over top as failsafe
- First CF shell set to a 1" bulge with foam mold.

HGC Window – Carbon Fiber



- First shell failed spectacularly.
- New shell made with depth increased to 1.5"
- Managed to hold 5 atm for nearly two months with no loss

HGC Window – Carbon Fiber



- Full size window a success!
- Almost...
- Reached 2 atm with no structural failure
- Maintained pressure for approximately one week
- Suddenly dropped to one atm one night, no longer held pressure

Conclusion

- Viable window material found – Carbon Fiber with Mylar sealing layer and Kevlar failsafe layer.
- Problems persist with window frame and/or O-ring
- Ongoing discussion of design changes with Duke University
- Full segment prototype forthcoming

Acknowledgements

- Derek Gervais and Lorenz Weber – U. Regina
- Gary Swift and Zhiwen Zhao – Duke University
- CFI, Fedoruk Center, and NSERC

Leading order GPDs

- E, H summed over quark helicity
- $\tilde{E}, \tilde{H}$ involve difference between right and left handed quarks
- $H, \tilde{H}$ conserve proton helicity
- $E, \tilde{E}$ allow for proton helicity to flip

$$\sum_q e_q \int_{-1}^{+1} dx H^q(x, \xi, t) = F_1(t),$$

$$\sum_q e_q \int_{-1}^{+1} dx E^q(x, \xi, t) = F_2(t),$$

$$\sum_q e_q \int_{-1}^{+1} dx \tilde{H}^q(x, \xi, t) = G_A(t),$$

$$\sum_q e_q \int_{-1}^{+1} dx \tilde{E}^q(x, \xi, t) = G_P(t),$$